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NINTH MONTHLY PROGRESS REPORT ON

DEVELOPMENT AND TESTING OF ELECTROLYTE MATRIX COMBINATIONS FOR MERCURY-POTASSIUM FUEL CELL

(12 August–12 September 1963)

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OTS:

PROGRESS OF WORK DURING REPORTING PERIOD

18219

Work to eliminate cracks in the fine grain composite continued. Three composites tested in small cells, each showing evidence of matrix cracking before tests were completed. The last cell gave more than 12 hr of open circuit performance under limited operating conditions.

Gas permeability testing to date indicates that the KOH-KBr-KI eutectic-MgO composite is gas tight up to 32 in. H_2O equivalent pressure.

AUTHOR

SMALL CELL TESTING

Three small cells (NASA-VI, -VII, and -VIII) were tested during this period. Each matrix was fabricated from fine grain electronic grade MgO.

Cell NASA-VI was made up from a 53% electrolyte fine grain composite with 86.2% of theoretical density. The total operating time was 14 min. The initial open circuit voltage, after K-metal loading, went to 1.28 volts for 3 min before an internal short caused unstable operation. The internal short increased progressively until it forced the terminal voltage to zero in 11 min. Posttest analysis indicated that the internal short was caused by potassium penetration of a crack in the matrix.

Cell NASA-VII was made from the same composite as cell NASA-VI, with a percent of theoretical density of 85.5. The total running time on this cell was 3 min. The initial open circuit voltage reached 1.34 volts within 24 sec, but a heavy internal load (short) dropped the terminal voltage to zero in 3 min. Posttest analysis showed fine cracks in the matrix.

Cell NASA-VIII was made with a screen supported 65% electrolyte composite. This matrix was highly saturated (93% of theoretical density). The total life of this cell was greater than 14 hr. The first two hours were used to test for Hg penetration under the normal 1.5 in. Hg head without potassium on the opposite side. The initial voltage of 1.35 volts occurred after only 5 gm of K-metal was splashed onto the matrix upon entering the cell chamber. All running was accomplished on this initial load of K-metal.

Electrical measurements recorded cell resistivity values from 3 ohm-cm to 4.3 ohm-cm. The limited contact area of K-metal would tend to produce a higher resistance than that for a fully loaded K-metal chamber. Open circuit voltages measured at the cell terminals ranged from 0.87 to 0.18 volts as a result of variations in internal loads over a 12-hr period. The voltage trace on the recorder was lost for the next 5.5 hr. Sometime during this 5.5-hr period the cell dead-shorted to zero voltage. Cell voltage was not recoverable, as evidenced by continuous charging.

COMPOSITE IMPROVEMENT AND FABRICATION

The method of bakeout in a coarse grain MgO composite has proved effective in reducing visible cracks and warpage in the specimens. Since it was found that some desaturation of the composite was caused by the packing, the percent electrolyte content is now based on spot analyses of specimens after the baking procedure. The composite preparation technique will make use of the fine grain electronic grade MgO and the newly developed, packed baking procedure. Effort now is to develop the larger specimens (4-in. × 1/8-in.) in crack-free form in addition to continued preparation of other shapes and sizes for various strength, compatibility, and cell tests.

GAS PERMEABILITY STUDY

Three 1 in. × 1/8 in. specimens were subjected to an argon gas pressure to check permeability at the cell operating temperature of 300°C. The test apparatus incorporated the same concentric serrated seal as used in the cell. Leak detection instrumentation was placed across the specimen and the seal. Results showed that in all three tests the seals did not leak. One specimen was tested up to 32 in. H_2O head without any detectable leaks. These tests show that the KOH-KBr-KI eutectic electrolyte-MgO composite is not gas permeable as opposed to reports by other investigators which state that carbonate electrolytes are permeable when used in conjunction with hydrocarbon-oxygen or air fuel cells.

CELL DESIGN AND CONSTRUCTION

The 3-in. diameter cell which will use the 4-in. diameter composite matrix is nearly ready for assembly within an oven. New silicone rubber O-rings have been received for this larger configuration. The larger cell test program will be scheduled when a greater "certainty of success" is indicated based on the small cell test program results.

WORK FOR NEXT REPORTING PERIOD

Work for the next period will include cell testing, including strength and conductivity measurements of specimens prepared from the present development techniques. Emphasis will be placed on small cell testing of prepared composites and composites which are altered or reprocessed within the scope of the cell testing work. This work might encompass such techniques as:

- Addition of electrolyte to the matrix within the cell and subsequent testing after aging at cell temperatures (300°C)
- Use of K-Hg amalgam as the anode
- Testing in a differential density cell (gravity cell) configuration to establish limits of performance of the matrix in a reliable test condition

Testing of large cells will be planned based on the results of small cell tests.

CUMULATIVE MAN MONTHS EXPENDED

	Through 12 August *	Through 12 September
Research	20.0	22.1
Shop	0.6	0.8
Materials Laboratory	14.7	16.8
Total	35.3	39.7

BUDGET

Research	30
Shop	2
Materials Laboratory	17

*Cumulative man months reported in eighth monthly progress report were in error.